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(पहला पुनरीक्षण)

Indian Standard
SOLID PRESSBOARD FOR ELECTRICAL PURPOSES — SPECIFICATION
(*First Revision*)

First Reprint JUNE 2007
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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

January 1992 **Price Group 8**

Solid Electrical Insulating Materials Sectional Committee, ETD 2

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FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Solid Electrical Insulating Materials Sectional Committee had been approved by the Electrotechnical Division Council.

This standard was first issued in 1967. This revision has been necessitated to take into account the recent advancement in technologies resulting in improved values of Tensile Strength, Compressibility, Conductivity of Aqueous Extracts, Compressibility in Air and Oil, etc, are being achieved in Classification Type C and Type D.

Pressboards are used as an insulating material, both in air and oil in a number of electrical equipments, for example, transformers and switchgears.

Requirements for various characteristics given in 4 are for pressboards used general purposes. For specific end uses all the tests are not necessary and tests recommended for pressboards intended for specific end uses have been given in Annex D.

This standard contains **5.5.0**, **5.17** and **5.18** which call for agreement between the purchaser and the supplier and which permit the purchaser to use his option for election to suit his requirements.

AMENDMENT NO. 1 FEBRUARY 2003
TO
IS 1576 : 1992 SOLID PRESSBOARD FOR ELECTRICAL PURPOSES — SPECIFICATION

(First Revision)

(*Foreword, para* 4, *line* 3) — Substitute 'Annex T' *for* 'Annex D'.

(*Page* 1, *clause* **5.2.1**) — Substitute the following for the existing:

5.2.1 *Tolerance on Normal Thickness* — The thickness of the board at any point when measured in accordance with Annex B shall not differ from nominal thickness as per the following deviation permitted for Types A, B, C and D:

Thickess	*Tolerance*
≤ 1.6 mm	±7.5 %
≥ 1.6 to 6.35 mm	± 5 %

[*Page* 3, *clause* **5.9**(b)] — Insert the following after **5.9**(b):

c) Pressboards with nominal thickness other than that indicated in Table 1 shall be tested either for number of folds as stated for next higher thickness in Table 1 or it shall be bent round a mandrel as stated for next higher thickness in Table 1.

(*Page* 3, *Table* 1) — Substitute the following for the existing table:

Table 1 Flexibility
(*Clauses* 5.9 *and* G-3.2)

Type	Direction	Nominal Thickness, mm							
		0.80	1.60	0.80	1.60	2.00	3.20	4.75	6.35
		No. of Folds		Mandrel Diameter in Millimetres					
A	Machine	50	30	—	—	19.00	—	—	—
	Cross	50	30	—	—	13.00	—	—	—
B	Machine	50	30	—	—	19.00	25.00	38.00	—
	Cross	50	30	—	—	6.50	13.00	25.00	—
C	Machine	50	20	—	—	19.00	25.00	38.00	76.00
	Cross	50	20		—	13.00	19.00	25.00	51.00
D	Machine	—	—	6.50	19.00	25.00	38.00	76.00	125.00
	Cross	—	—	3.25	6.50	13.00	19.00	38.00	51.00

1—80 BIS/ND/07

(*Page* 4, *clause* **5.11**. *informal table*) — Substitute the following for the existing:

Type	*Oil Absorption, Percent*
B	*15*
C	*20*
D	*15*

(*Page* 4, *clause* **5.13**. *informal table*) — Substitute 'micro ohms/cm' *for* 'mho/cm'.

(*Page* 7, *Annex* D, *clause* **D-3.1**, *line* 2) — Substitute 'sine-wave' *for* 'size-wave'.

(*Page* 7, *Annex* D, *clause* **D-3.1**, *line* 3) — Substitute '$\sqrt{2 \pm 5}$' *for* '2 ± 5'.

(*Page* 10, *Annex* F, *clause* **F-7.1**, *line* 2) — Substitute 'oven' *for* 'over'.

(*Page* 10, *Annex* F, *clause* **F-7.3**(b))] – Substitute 'h_2' *for* 'h_1'.

(*Page* 14, *Annex* P, *Title*) — Substitute the following for the existing:

DETERMINATION OF FREEDOM FROM CONDUCTING PARTICLES

(*Page* 14, *Annex* P, *clause* **P-3.2**, *line* 2) –Substitute '2.0 kV/mm' *for* 4.0 kV/mm'.

(ET 02)

Indian Standard
SOLID PRESSBOARD FOR ELECTRICAL PURPOSES — SPECIFICATION
(First Revision)

1 SCOPE

1.1 This standard prescribes the requirements and methods of sampling and test for solid pressboards, dyed or of natural colour, having a calendered finish and supplied in an unimpregnated condition.

1.2 It does not cover strawboard (not considered desirable for electrical purposes) and laminated material (made by combining several sheets of pressboard with an adhesive) and press-paper.

2 REFERENCES

2.1 The standards given in Annex A have been referred in this standard.

3 TERMINOLOGY

3.0 For the purpose of this standard, the following definitions shall apply.

3.1 Pressboard

Pressboard denotes the material which is made from vegetable fibres usually on an intermittent board machine and afterwards, subject to pressure to remove excess of water to consolidate the plies and close up the material, thus producing the board. The boards are afterwards dried and subsequently calendered.

3.2 Machine Direction

The direction parallel to that in which the material travelled during manufacture.

3.3 Cross Direction

The direction at right angles to that in which the material travelled during manufacture.

3.4 Perpendicular Direction

The direction at right angles to the surface of the material.

4 CLASSIFICATION

4.1 The specification covers the following four types of pressboards:

Type A — A dense pressboard of high chemical purity having good electrical and mechanical properties commonly intended for use in refrigeration coolants and in air. This type is usually made from 100 percent cotton.

Type B — A dense pressboard having good electrical and mechanical properties combined with flexibility and suitable for use in air or oil. This type is also usually made from 100 percent cotton.

Type C — A soft porous, untreated pressboard with oil absorption greater than Types B and D. It has good electrical properties in oil and is intended primarily for use in that medium. This type is usually made from a mixture of cotton and other fibres, such as jute and wood pulp.

Type D — A hard pressboard more rigid than Types A, B and C and characterised by good mechanical properties. This type is usually made from 100 percent woodpulp. The type is suitable for use both in air and oil.

5 REQUIREMENTS

5.1 Composition

The pressboards of any type covered by this specification shall be made entirely from vegetable fibres and where necessary, a suitable dye-stuff, and shall be free from extraneous matter.

5.2 Thickness

The thickness of the four types of Pressboards covered by this standard shall be as follows :

Type	*Range of Thickness* mm
A	0.75 to 2.00
B	0.75 to 5.00
C	0.75 to 6.35
D	0.75 to 6.35

5.2.1 *Tolerance on Normal Thickness*

The thickness of the board at any point when measured in accordance with Annex B shall not differ from the nominal thickness by more than ± 5 percent for Types A, B, C and D.

5.3 Finish

Sheets of pressboards shall generally have a smooth calendered finish.

5.4 Density

The density of the pressboards when determined by the method detailed in Annex C shall be as given below:

Type	*Density*	
	Min g/cm³	*Max* g/cm³
A	1.15	—
B	1.10	—
C	0.90	1.10
D	1.10	—

5.5 Electrical Strength (Proof Test)

5.5.0 The decision as to whether Types B and D shall be tested in air or oil shall be subject to agreement between the purchaser and the supplier.

5.5.1 *In Air*

When tested in accordance with Annex D, pressboards of Types A, B and D and of thickness not exceeding 3 mm shall withstand for one minute without failure the voltage appropriate to the nominal thickness as given in Fig. 1.

5.5.2 *In Oil*

When tested in accordance with Annex D pressboards of Types B, C and D shall withstand for 1 minute without failure the voltage appropriate to the nominal thickness as shown in Fig. 2.

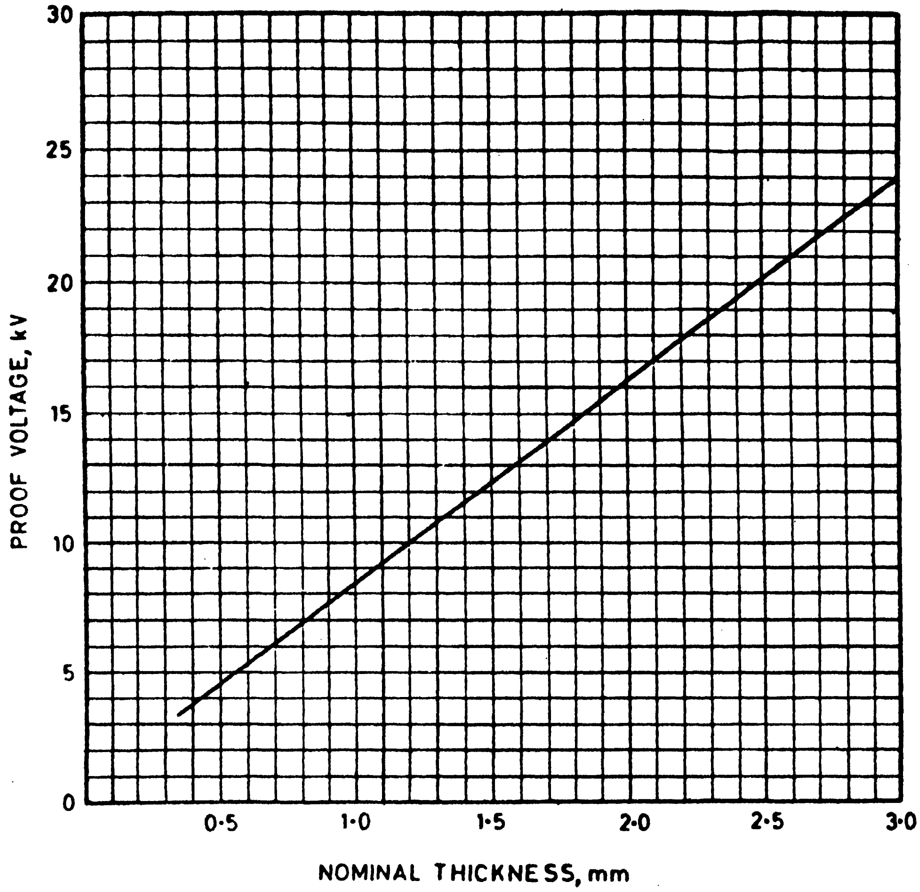


Fig. 1 Electric Strength (Proof Test) in Air at 90°C

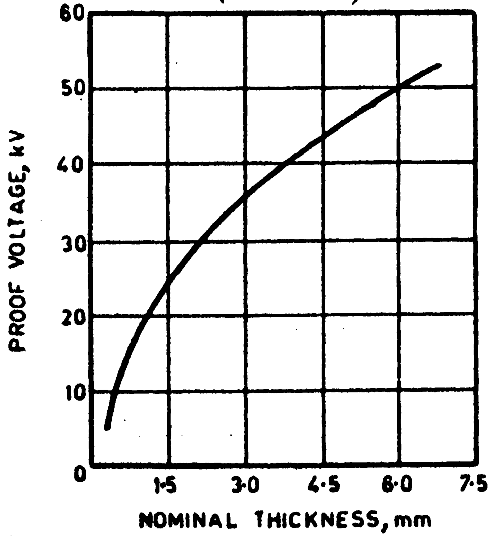


Fig. 2. Electric Strength (Proof Test) in Oil at 90°C

5.6 Tensile Strength

The tensile strength of the pressboards when tested in accordance with Annex E shall be not less than those given below:

Type	*Minimum Tensile Strength*	
	Machine Direction kg/cm^2	*Cross-Direction* kg/cm^2
A	630	320
B	630	320
C	500	250
D	800	400

5.7 Compressibility

The compressibility of the pressboards when tested in accordance with Annex F shall not exceed the value specified below :

Type	*Compressibility in Air* percent	*Total Compressibility After Subsequent Oil Immersion* percent
A	10	—
B	10	14
C	8	12
D	5	9

5.8 Shrinkage

5.8.1 *In Air*

The shrinkage of the pressboards due to drying in air when tested in accordance with Annex G shall not exceed the appropriate values specified below:

Type	*Maximum Shrinkage*		
	Machine direction Percent	*Cross direction Percent*	*Perpendicular direction Percent*
A	1.0	1.5	4.0
B	1.0	1.5	4.0
C	1.0	1.5	4.0
D	1.0	1.5	6.0

5.8.2 *In Oil*

The shrinkage in oil of the dried test pieces of Types B, C and D when tested in accordance with Annex G shall not exceed 0.3 percent in machine and cross machine direction and 1.5 percent in the perpendicular direction.

5.9 Flexibility

The pressboard shall withstand, when tested in accordance with Annex H, the following :

a) The appropriate number of folds specified in Table 1 without actual splitting or parting of either surface ply across the full width of the test piece; or

b) Bending round a mandrel of the appropriate diameter stated in Table 1 without sign of splitting or cracking of either surface or delaminating along the plies.

Table 1 Flexibility

(*Clauses* 5.9 *and* G-3-2)

Type	*Direction*	*Nominal Thickness*, mm									
		0.40	0.50	0.80	1.60	0.80	1.60	2.00	3.20	4.75	6.35
		No. of Folds				Mandrel Diameter in Millimetres					
A	Machine	—	50	50	30	—	—	19.00	—	—	—
	Cross	—	50	50	30	—	—	13.00	—	—	—
B	Machine	50	50	50	30	—	—	19.00	25.00	38.00	—
	Cross	50	50	50	30	—	—	6.50	13.00	25.00	—
C	Machine	—	50	50	20	—	—	19.00	25.00	38.00	76.00
	Cross	—	50	50	20	—	—	13.00	19.00	25.00	51.00
D	Machine	—	20	—	—	6.50	19.00	25.00	38.00	76.00	125.00
	Cross	—	20	—	—	3.25	6.50	13.00	19.00	38.00	51.00

5.10 Cohesion Between Plies

The cohesion between plies of pressboards of Types A, B and D shall be such that when tested in accordance with Annex J, the split shall rupture or tear one or more plies.

5.10.1 Pressboards of Type C shall not readily split by delamination, that is, between two adjacent plies and the exposed torn surfaces shall have a distinctly or ragged appearance.

5.11 Oil Absorption

Oil absorption of pressboards of Types B, C and D when tested in accordance with Annex C shall be not less than the appropriate values specified below:

Type	*Oil Absorption Percent*
B	15
D	15

5.12 Machinability

All pressboards shall be capable of being sheared. Pressboards of thicknesses 3.0 mm or below shall also be capable of being punched without showing ragged edges.

5.13 Conductivity of Aqueous Extract

The conductivity of aqueous extract when tested in accordance with Annex K shall not exceed the values specified below :

Type	*Maximum Conductivity* mho/cm
A	75
B	110
C	70
D	80

5.14 *p*H Values of Aqueous Extract

The *p*H value of aqueous extract when tested in accordance with Annex L shall be within the limits specified below:

Type	*pH Value*	
	Min	*Max*
A	7.0	10.0
B	7.0	9.0
C	7.0	9.5
D	5.0	9.5

5.15 Moisture Content

The moisture content of all types of pressboards as received shall not exceed 8 percent when tested in accordance with Annex M.

5.16 Mineral Ash

The mineral ash in the pressboards when tested in accordance with Annex N shall not exceed the values specified below:

Type	*Mineral Ash Percent*
A	1
B	2
C	2
D	1

5.17 Freedom from Conducting Particles

When required by agreement between the purchaser and the supplier, pressboards up to and including 1.6 mm shall be free from conducting particles when tested in accordance with Annex P.

5.18 Conductivity of Organic Extract

When required by agreement between the purchaser and the supplier, the conductivity of the organic extract as determined by the method described in Annex Q shall not be greater than 10^{-10} mhos/cm.

6 MARKING

6.1 The consignment of pressboards shall be legibly and indelibly marked on a suitable place with the following information:

a) Manufacturer's name or trade-mark, if any;

b) Type of pressboard; and

c) Thickness.

6.2 The pressboards may also be marked with the Standard Mark.

7 SAMPLING AND CRITERION FOR CONFORMITY

7.0 For production control, use of control chart techniques is recommended to the manufacturer (*see* IS 327 : 1961). The results of such tests done at the place of manufacture may be made available to the purchaser to satisfy him that the material produced by the manufacturer is generally of the specified quality. In addition to the above facility to the purchaser, he may ascertain for himself that the material received by him conforms to this specification, by adopting the procedure given in 7.1 to 7.4.3.3.

7.1 Lot

In any consignment of the press-boards of the same type and thickness manufactured under essential similar conditions of production shall be grouped together to form a lot.

7.1.1 Each lot shall be sampled separately for ascertaining its conformity to the requirements of the specification.

7.2 Scale of Sampling

The number of press-boards to be selected from a lot, depending on the lot size, shall be as given below:

Lot Size *N*	*Sample Size* *n*	*Permissible No. of Defectives*
Up to 100	20	2
101 to 300	32	3
301 to 500	50	5
501 and above	80	7

7.2.1 The sheets shall be selected at random from the lot. Recommended procedure is given below:

> Arrange all the sheets in the lot in a systematic manner and starting from any sheet, count then as 1, 2, 3, ... up to *r* and so on, where *r* is the integral part of N/n (*see* 7.2). Every *r*th sheet thus counted shall be withdrawn to constitute the sample.

7.3 Number of Tests

7.3.1 All sheets selected in accordance with 7.2 shall be inspected for appearance, flatness and thickness.

7.3.2 For the remaining characteristic five sheets shall be selected from the sample irrespective of the sample size. Tests shall be conducted on the specimen drawn from them.

7.3.3 While specimens are cut from the boards, ensure that no part of any test piece is from a position less than 25 mm from the edge of the board as received.

7.4 Criterion for Conformity

7.4.1 A lot shall be declared as conforming to the requirements of the specification if the results of testing satisfy the conditions stipulated in 7.4.2 to 7.4.3.3; otherwise not.

7.4.2 The number of sheets in the sample failing to meet the requirements for finish and tolerance on thickness shall be less than or equal to the corresponding permissible number of defectives given in 7.2.

7.4.3 For tensile strength, compressibility, shrinkage, oil absorption, moisture content, conductivity of aqueous extract, *p*H value and mineral ash, the mean ($\bar{X}$) and range (R) of the corresponding five test results shall be calculated (range is defined as the difference between the maximum and minimum values of the results).

7.4.3.1 The conformity of the lot to requirements of tensile strength and oil absorption shall be declared only if the expression $\bar{X} - 0.5R$ and $\bar{X} + 0.5R$ calculated from the relevant test results, is greater than or equal to the corresponding requirements.

7.4.3.2 The conformity of the lot to the requirements of compressibility, shrinkage, moisture content, mineral ash, conductivity of aqueous extract and conductivity of organic extract shall be declared only if the expression $\bar{X} - 0.5R$ and $\bar{X} + 0.5R$, as calculated from the relevant test results, is less than or equal to the corresponding requirements.

7.4.3.3 The conformity of the lot to the requirements of *p*H value of aqueous extract shall be declared if all the following three conditions are satisfied:

1. $\frac{R}{U-L} \leq 0.857$
2. $\bar{X} - 0.5R > L$
3. $\bar{X} + 0.5R < U$

Where L and U are lower and upper specification limits of *p*H value.

7.4.3.4 The conformity of the lot to the requirements of flexibility, cohesion between plies and machinability shall be declared only if all the five sample sheets selected for the purpose pass the corresponding tests.

ANNEX A

(*Clause* 2.1)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
327 : 1961	Specification for oil of lemongrass (East Indian oil of lemongrass) (*revised*)
335 : 1983	Specification for new insulating oils (*third revision*)
2967 : 1983	Specification for external micrometers (*first revision*)
1570 : 1961	Specification for schedules for wrought steels for general engineering purposes
1876 : 1961	Method for voltage measurement by means of sphere-gaps (one sphere earthed)

ANNEX B

(*Clause* 5.2.1)

DETERMINATION OF THICKNESS

B-1 AS RECEIVED

B-1.1 To ascertain if the thickness of the board complies with the requirements of **5.2**, measurements of thickness shall be made on the board in the condition as received with a micrometer (*see* IS 2967 : 1983) at 10 points equally spaced around the 4 sides of the board.

B-2 AFTER NORMAL CONDITIONING

B-2.1 In case of doubt, a strip 40 mm wide shall be cut from one end of the board and along the entire cross direction. Ten specimens each not less than 40 mm long shall be cut from 10 positions equally spaced along the strip. The specimens shall be conditioned as described in Annex R and the thickness of each specimen shall then be measured with a micrometer, one measurement being made at approximately the central position on each specimen. The mean thickness compared from these measurements shall be deemed to be the thickness of the board.

ANNEX C

(*Clauses* 5.4 *and* 5.11)

DETERMINATION OF DENSITY AND OIL ABSORPTION

C-1 DENSITY

C-1.1 Procedure

Dry a test piece, approximately 75 x 75 mm in accordance with Annex S and on its removal from the above, allow it to cool in a desiccator and determine its weight to the nearest milligram. Compute the area of the test piece from the means of two measurements of length and width respectively at points equally spaced along each of two edges at right angles.

Determine the thickness by making ten measurements with suitable micrometer at points equally spaced around the sides and the mean value shall be taken in computing the volume of the specimen. Then express the density as the weight in grams per cubic centimetre of dried piece.

C-2 OIL ABSORPTION

C-2.1 The samples after density determination are immediately immersed in insulating oil complying with IS 335 : 1983 at a temperature of 105 ± 2°C for 72 hours. Then take the test piece from the oil, remove surplus oil with blotting paper and reweigh the test piece. Compute the percentage absorption of oil on the weight of the dry test piece before immersion.

ANNEX D

(*Clauses* 5.5.1 *and* 5.5.2)

DETERMINATION OF ELECTRIC STRENGTH (PROOF TESTS)

D-0 GENERAL

D-0.1 The proof test on the test piece of electric strength is conducted at 90 ± 2°C either in air or immersed in oil complying with IS 335 : 1983.

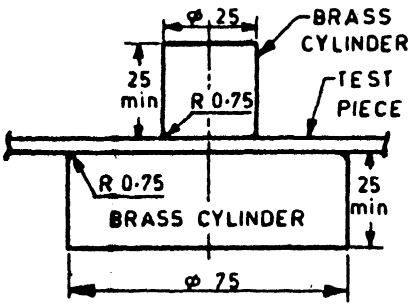
D-1 TEST PIECE

D-1.1 Test piece shall be 300 × 300 mm.

D-2 ELECTRODES

D-2.1 The electrodes for testing consist of two solid brass cylinders with their sharp edges rounded off to a radius of approximately 0.75 mm. The top and bottom electrodes shall be 25 and 75 mm in diametres respectively and not less than 25 mm in height.

D-2.2 When the surface of the specimen is irregular or any difficulty is experienced in obtaining good contact, it is recommended that tin foil should be interposed between the electrodes and the specimen. Arrange the electrodes coaxially as shown in Fig. 3.



All dimensions in millimetres.

FIG. 3 ARRANGEMENT OF ELECTRODES FOR ELECTRIC STRENGTH (PROOF TEST)

D-3 TEST VOLTAGE

D-3.1 The test voltage applied when the specimen is in circuit shall be approximately of size-wave form with crest factor equal to 2 ± 5 percent, that is, 1.35 to 1.49.

D-3.2 The crest factor may be checked by means of an oscillograph, a sphere gap or a crest voltmeter in conjunction with an rms voltmeter. The measurement should be made across the material under test. The test voltage shall be expressed as its peak value divided by 2. The frequency of the test voltage shall be between 40 and 60 Hz.

D-4 MEASUREMENT

D-4.1 The peak voltage may be measured directly by means of a peak voltmeter. Alternatively, the voltage may be determined by a voltmeter suitably connected to the input and output side of the testing transformer or to a voltmeter winding provided thereon. If this alternative procedure is adopted, the instrument used should be calibrated against a sphere gap up to the full voltage which is to be measured.

D-4.2 The ratio of the voltage derived from the sphere gap to the voltage indicated on the auxiliary instrument may be dependent upon the presence of the test object or of the sphere gap. It is, therefore, important that the test object or an equivalent load should be in the circuit during calibration. The sphere gap may be disconnected during the actual test, if the absence is known to have a negligible influence on the voltage ratio (*see also* IS 1876 : 1961).

D-4.3 Use test equipment capable of maintaining the test voltage up to the instant of breakdown or for the maximum time required.

NOTE – This requirement is usually met by equipment capable of supplying an output current of not less than 40 mA over the range for which it is intended at all leading power factors between zero and unity.

D-5 PROCEDURE

D-5.1 Test in Air

Dry the test piece in accordance with Annex S and on removal of the test piece from the oven reduce the temperature to 90 ± 2°C and place the electrodes previously heated to 90°C in position on the test piece.

D-5.2 Test in Oil

Dry the test piece in accordance with Annex C and on removal of the test piece from the oven, immerse it immediately in insulating oil at 90 ± 2°C for 72 hours. Then place the test piece between the electrodes previously heated to 90°C, and immerse the whole assembly in the oil. Maintain the oil at 90 ± 2°C for not less than 15 minutes before applying the voltage.

D-6 APPLICATION OF VOLTAGE

D-6.1 Apply the voltage between the electrodes and raise it to the appropriate proof voltage derived from Fig. 1 or Fig. 2 as rapidly as possible consistent with its accurate attainment without any transient overvoltage. Maintain the proof voltage for 1 minute.

ANNEX E

(*Clause* 5.6)

DETERMINATION OF TENSILE STRENGTH

E-1 TEST PIECE

E-1.1 The form and dimensions of the specimen for test shall be as shown in Fig. 4, or alternatively use strips of uniform width from 12.5 mm to 25.0 mm. The thickness of the specimen shall be the thickness of the sheet under test. The free length of each test piece between the jaws of the testing machine shall be not less than 150 mm.

E-1.2 Use three test pieces cut in each of the machine and cross directions. In cutting test pieces from the board under test no part of any test piece shall be cut from a position nearer than 25 mm from the edge of the board as received.

E-1.3 If the machine and cross direction are not known, cut a test piece with its length in a direction parallel to one side of the board and another in the direction at right angles (*see* Fig. 5). The test piece having the greater value of tensile strength is deemed to have been cut with its length in the machine direction of the board.

E-2 CONDITIONING

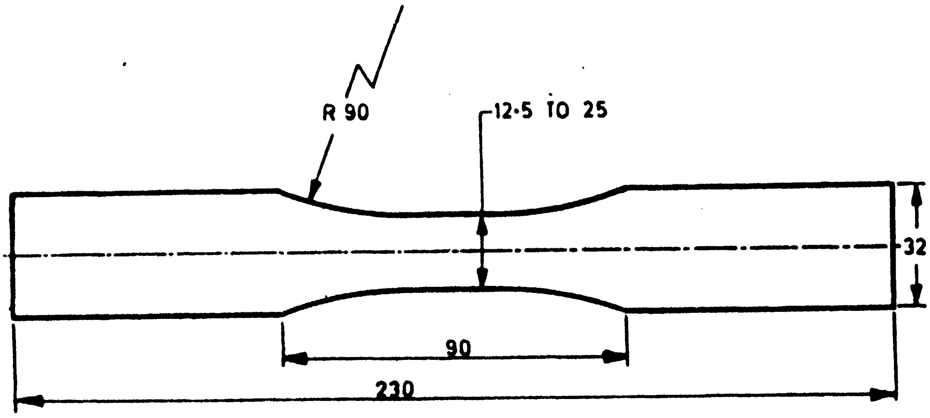
E-2.1 Condition the test pieces in accordance with Annex R.

E-3 PROCEDURE

E-3.1 Measure the thickness and width of each test piece on removal from the conditioning atmosphere. Make the test at a temperature of 10°C to 40°C. Apply the load steadily so that the time taken to reach the breaking load from the commencement of application of the load is not less than 30 seconds. Disregard the results of test pieces breaking within the jaws.

E-4 RESULTS

E-4.1 Report the machine and cross machine tensile strength in kilogram per square centimetre calculated as the mean of the results from the three test pieces cut in each direction.



All dimensions in millimetres.

FIG. 4 TENSILE STRENGTH TEST PIECE

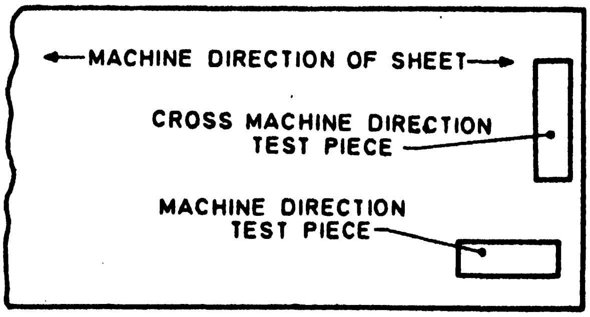

←MACHINE DIRECTION OF SHEET→
CROSS MACHINE DIRECTION TEST PIECE
MACHINE DIRECTION TEST PIECE

FIG. 5 DIRECTIONS IN WHICH TEST PIECES ARE CUT FROM SHEETS

ANNEX F

(*Clause* 5.7)

DETERMINATION OF COMPRESSIBILITY

F-1 PRINCIPLE

F-1.1 A pad of pressboard washers is subjected to loading by means of a spring pressure in a specified apparatus. An initial small load of 135 kg (bedding load) is applied by one spring to consolidate the pad and the thickness of the pad is measured. The load is then increased to 1 350 kg by bringing into operation a second spring and the new thickness h_1 measured. The percentage change in thickness is referred to the thickness h under the bedding load.

F-1.2 Without further adjustment, the test equipment, exerting a pressure of 1 350 kg is immersed in insulating oil conforming to IS 335 : 1983 and maintained at 105 ± 2°C for 24 hours. The equipment is then removed from the oil and allowed to cool at room temperature when the final thickness h_2 of the pad is determined. The percentage change in thickness of the pad is referred to the thickness under the bedding load.

F-2 TEST PIECE

F-2.1 Prepare the test pieces, all from the same board, in the form of washers 20 mm ± 0.05 mm internal diameter, 35 ± 0.05 mm external diameter, and providing an annular surface of nominal area 645 mm². Sufficient number of washers to build a pad of 25.0 mm high should be taken. Care is to be taken throughout the preparation to avoid contamination of the washers.

F-2.2 It is essential that the washers are concentric and have clearly cut inner and outer edges; any burrs left by machining operations are removed but no more of the original surface is removed than is necessary to effect this. Washers showing any sign of delamination shall be rejected. No part of any washer shall be from a position nearer than 25 mm from the edge of the board as received. Should several washers be machined in a clamp, the clamping pressure applied shall be no more than necessary to faciliate the machining operations. In all cases the two end washers shall be discarded on completion of machining.

F-3 MACHINING

F-3.1 This method is suitable for material of all thickness. Sufficient planks at least 38 x 38 mm, cut with a guillotine or band saw and placed betwen two packing pieces of similar sizes of synthetic resin paper base board. Supported by a V-block, the planks and the packing pieces are then assembled between a 3 jaw self-centering chuck and the tail stock of a lathe. When they are firmly clamped between the tail stock and the chuck, the V-block is removed and the planks are turned to the correct diameter.

F-3.2 On removal of the assembly from the lathe, the jaws of the chuck are opened to receive the pressboard discs and these are pressed together in the chuck using one synthetic resin paper base board disc and the tail stock. The jaws of the chuck are then carefully lightened on the disc and the tail stock and packing disc is withdrawn. The tail stock centre is removed and replaced by a 20 mm high speed steel drill. With a chuck revolving at a speed of 700 to 750 rev/min the discs are then drilled.

F-4 PUNCHING

F-4.1 This method is suitable for material not more than 3.0 mm thick. Sufficient blanks in the form of discs of at least 37.50 mm diameter are cut from the board under test. The centre hole of the washer is then punched out of each blank; these are then slid on to a mandrel and held between steel washers for the machining of annulus to the correct outside diameter.

F-5 DRILLING BETWEEN TEMPLATES

F-5.1 This method is suitable for material more than 3.0 mm thick. Two steel plates 9.5 mm thick and of sufficient area (30 x 15 cm is satisfactory) are drilled through at intervals of not less than 37.50 mm centres to provide concentric guide holes, 20 ± 0.050 mm diameter through which the centre holes of pressboard washers are drilled. The plates are fitted with bolts around the edges and in the centre to clamp them together.

F-5.2 A test piece of sufficient area is clamped between the templates and centre holes of the number of washers required are drilled with a 20-mm drill. The test piece is then removed and cut into 40 x 40 mm concentric with the drilled holes. These square pieces are then slid on to a mandrel and held between two steel washers to be machined to the correct outside diameter.

F-6 APPARATUS

F-6.1 Springs

Use a test apparatus of type shown in Fig. 6 which employs springs for applying the lead. Essential details of the springs are:

Outer Spring

Material	Spring steel (*see* IS 1570 : 1961)
Diameter of wire	15.25 mm
Number of free turns	9
Overall length	20.32 cm
Internal diameter	7.30 cm
Both ends to be finished	Flat
Spring characteristic, deflection for a load of 135 kg at room temperature	12.70

Inner Spring

Material	Spring steel (*see* IS 1570 : 1961)
Diameter of the wire	17.45 mm
Number of free turns	9
Overall length	19.05 cm
Outer diameter	7.00 cm
Both ends to be finished	Flat
Spring characteristics deflection for a load of 1.350 kg at room temperature	15.875 mm

F-6.2 In operation, the outer spring is compressed up to 135 kg and thereafter both springs are involved.

F-6.3 The test equipment is calibrated as a unit to an accuracy of 2 percent and checked at least annually. A scale indicates the position of which 135 kg and 1 350 kg are applied to the test piece.

F-6.4 Periodically check the parallelism and the smoothness of the platens.

F-7 PROCEDURE

F-7.1 Compressibility in Air

Dry the requisite number of washers loose in accordance with Annex M. On removal from the over, allow them to cool in a desiccator to a temperature between 10°C and 40°C. Immediately on removal from the desiccator, assemble the washers concentrically as a pad of thickness not exceeding 25.0 mm. Apply a bedding load of 135 kg to the pad. After 1 minute has elapsed measure the thickness of the pad, represented by the distance between the upper and lower platens adjacent to the pad, by taking four measurements on two diameters at right angles using expanding calipers as near to the pad as possible. Calculate the mean of the four measurements which should be deemed the thickness h of the pad under the bedding load.

Increase the load to 1 350 kg including the bedding load and after allowing 1 minute to elapse, measure the thickness h_1 of the pad as before.

F-7.2 Total Compressibility After Subsequent Oil Immersion

Without further adjustment of load of 1 350 kg on the pad, immediately immerse the equipment in insulating oil conforming to IS 335 : 1983 at 105 ± 2°C for 24 hours. On removal from the oil, allow the equipment to cool to room temperature and determine the thickness h_2 of the pad as before.

F-7.3 Result

Report the compressibility in air and total compressibility after subsequent oil immersion as the percentage change in thickness of the pad of washers referred to the thickness under the bedding load.

Express the percentage compressibility as follows:

a) Compressibility in air $= \dfrac{h - h_1}{h} \times 100$

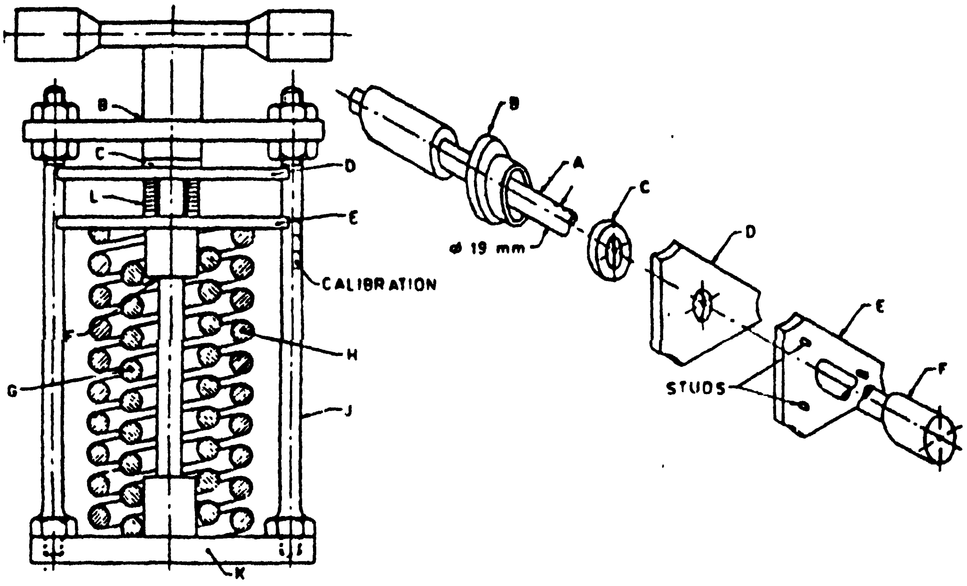
b) Total compressibility after subsequent oil immersion $= \dfrac{h - h_1}{h} \times 100$

where

h = thickness under bedding load of 135 kg in air,

h_1 = thickness under compressive load of 1 350 kg in air, and

h_2 = thickness under compressive load of 1 350 kg in oil.



A = SHAFT
B = TOP LOCATING BUSH
C = WASHER
D = TOP PRESSURE PLATE
E = BOTTOM PRESSURE PLATE
F = BOTTOM LOCATING BUSH
G = TEST LOADING SPRING
H = BEDDING PRESSURE SPRING
J = GUIDE RODS
K = BASE PLATE
L = TEST PIECES

FIG. 6 COMPRESSION TEST APPARATUS

ANNEX G

(*Clauses* 5.8.1 *and* 5.8.2)

DETERMINATION OF SHRINKAGE

G-1 TEST PIECE

G-1.1 The test piece shall be approximately 75 × 75 mm cut with one edge parallel to the machine direction of the board. In cutting the test piece ensure that no part of the test piece is from a position less than 25 mm from the edge of the board as received.

G-2 CONDITIONING

G-2.1 Condition the test piece in accordance with Annex R.

G-3 PROCEDURE

G-3.1 The dimensions of the test piece should be measured immediately on removal from the conditioning atmosphere. Determine the length and the width as the means of two measurements of each dimension taken at points approximately 13 mm from the corners of the test piece. Determine the thickness as mean of eight measurements equally spread around the sides of the test piece :

a) *Shrinkage in Air*

The test piece shall be dried in accordance with Annex S. Allow it to cool in a desiccator to a temperature between 10°C and 40°C. Immediately measure the dimensions as before; and

b) *Shrinkage in Oil*

On completion of G-3.1 a), immerse the test piece in insulating oil conforming to IS 335 : 1983 at 105 ± 2°C for 120 hours. On removal of the test piece from the oil, wipe off excess oil and after allowing it to cool between 10°C and 40°C. Measure the dimensions as before.

G-4 RESULTS

G-4.1 Calculate the shrinkage in air as the percentage change in dimensions on the original measurements of the conditioned test piece.

G-4.2 Calculate the shrinkage in oil as the percentage change in dimensions on the measurements of the test piece dried in air.

ANNEX H

(*Clause* 5.9)

DETERMINATION OF FLEXIBILITY

H-1 TEST PIECES

H-1.1 Three test pieces 25 × 300 mm shall be cut from both the machine and cross directions of the board under test. In cutting these ensure that no part of any test piece is from a position less than 25 mm from the edge of the board as received.

NOTE — If the machine and cross directions are not known, they may be ascertained from the results of tensile strength test (*see* Annex E).

H-2 CONDITIONING

H-2.1 Condition the test pieces in accordance with Annex R.

H-2.2 The tests shall be conducted between 10°C and 40°C.

H-3 FOLDING TEST

H-3.1 Fold the test piece back on itself and with reasonable finger pressure only, make an initial crease across the width. For the purpose of computing the total number of folds in the test ignore this preliminary treatment.

H-3.2 On the same crease fold the test piece flat on itself in the reverse direction thus completing one fold through 360°. Repeat this operation alternately in reverse directions for the number of folds specified in Table 1. To make each fold, use reasonable finger of pressure only.

H-3.3 Examine the surfaces of each test piece for evidence of splitting or parting of either surface ply across the full width of the test piece.

H-4 BENDING TEST

H-4.1 Each test piece shall be slowly bent through 90° around a mandrel of approximate diameter specified in Table 1. This test is to be made manually and care taken that the test piece is bent smoothly and closely to the mandrel.

H-4.2 Examine the bend in each test piece for evidence of splitting or cracking of either surface or delamination along the plies.

ANNEX J

(*Clause* 5.10)

DETERMINATION OF COHESION BETWEEN PLIES

J-1 TEST PIECE

J-1.1 The test piece shall be approximately 75 × 75 mm. In cutting this ensure that no part of the test piece is from a position less than 25 mm from the edge of the board.

J-2 CONDITIONING

J-2.1 The test piece shall be conditioned in accordance with Annex R.

J-3 PROCEDURE

J-3.1 Immediately on removal from the conditioning atmosphere start to split the test piece into two parts of similar thickness by inserting a knife blade at one corner and complete the separation by pulling the test piece with the finger.

J-3.2 Examine the exposed surfaces for conformity with **5.10** ignoring the corner areas split with the knife.

ANNEX K

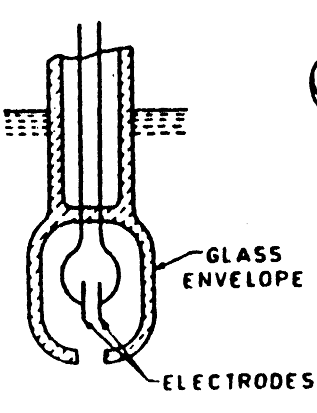
(*Clause* 5.13)

DETERMINATION OF CONDUCTIVITY OF AQUEOUS EXTRACT

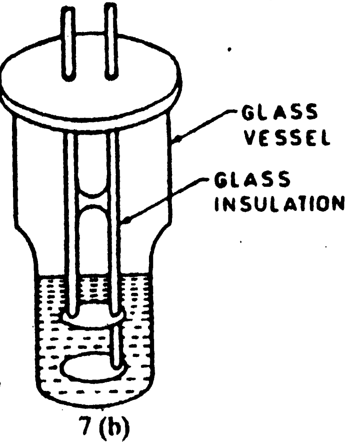
K-1 APPARATUS

K-1.1 A suitable conductivity cell is required in conjunction with a bridge circuit supplied with current at a frequency of 500 to 3 000 c/s.

K-1.2 A suitable cell consists of two electrodes of inert metal, for example, platinum maintained at a fixed distance apart and adequately insulated from each other. In one type (immersion cell) the electrodes and limits the fringing current but allows full access of the test liquid to the electrodes during the immersion [*see* Fig. 7 (a)]. In the kohlrausch type of cell [*see* Fig. 7 (b)], the extract is contained in a special glass vessel the side of which merely touch the edges of the electrodes when the cell is assembled. It is important that any insulation which is immersed in the test liquid shall not be water absorbent or subject to contamination by aqueous electrolytes. The cell should be easy to clean and free from recesses where impurities can be retained.



7 (a)



7 (b)

FIG. 7 (a) IMMERSION OR DIP TYPE ELECTRODES

FIG 7 (b) KOHLRAUSCH TYPE ELECTRODES

K-2 PREPARATION OF EXTRACT

K-2.1 Use distilled water with a conductivity not greater than 2 micromhos/cm. Make a blank test before each extraction and if the resultant conductivity exceeds 2 micromhos/cm, repeat the test with the same extraction vessel; discard the vessel if the second result also exceeds 2 micromhos/cm.

K-2.2 Prepare the extract by cutting the pressboard into strips approximately 20 × 3 mm. Weigh 5 g of the strips and immerse in 100 ml of distilled water in a round bottomed borosilicate quartz or glass flask, fitted with interchangeable conical ground glass joints. Boil the water gently for 60 minutes taking care that the pressboard is not charred, then allow it to cool as rapidly as possible using carbon dioxide trap fitted to the condenser.

NOTE — For material more than 1.5 mm thick, delamination of the sample is permissible to facilitate preparation of the test piece.

K-3 METHOD OF MEASUREMENT

K-3.1 Determination of Cell Constant

K-3.1.1 Determine the cell constant *K*, if not known by means of a solution of known specific conductivity prepared by dissolving 0.074 6 g of dry potassium chloride in low conductivity water and diluting the solution to 1 000 ml at a temperature of 20°C. Rinse the cell throughout with the solution and then fill. Maintain the temperature at 25 ± 1°C for 15 minutes and then measure the resistance R in megohms at that temperature.

K-3.1.2 Make a measurement of the resistance R_0 in megohms of the cell filled with water used for the preparation of the potassium chloride solution, the cell having been thoroughly rinsed out with this water before filling. The cell constant is then calculated as:

$$K = \frac{147.4\,R}{1 - R/R_o} \qquad \text{(for } K \text{ and } R, \textit{ see } \text{K-3.1.1)}$$

K-3.2 Determination of Conductivity of Blank

After thoroughly cleaning the cell with low conductivity water fill the cell with water obtained as a result of the blank extraction test and measure its resistance R_1 in megohms. The conductivity of the blank in micromhos/centimetre is then given by K/R_1.

K-3.3 Determination of Conductivity of Water Extract

K-3.3.1 Thoroughly rinse the cell with the extract to be tested and then fill with the extract. Adjust the temperature to 25 ± 1°C, maintain at that value for 15 minutes, and then measure the resistance R_2, in megohms at that temperature.

K-3.3.2 The conductivity of the water extract in micromhos/centimetre is then calculated as K/R_2.

NOTE – For most purposes where it is not convenient to test the water extract at 25 ± 1°C, it is sufficiently accurate to apply the following corrections :

$$\text{Conductivity at } 25^{\circ}\text{C} = \frac{G}{1 + 0.02\,(t - 25)}$$

where

G = conductivity obtained when the measurement is made at t °C.

K-4 PRECAUTIONS

K-4.1 In storage of samples of pressboards for test of conductivity of aqueous extract take care that they are not contaminated by the atmosphere particularly the atmosphere of a chemical laboratory.

ANNEX L

(*Clause* 5.14)

DETERMINATION OF *p*H VALUE

L-1 PREPARATION OF EXTRACT

L-1.1 Prepare an aqueous extract of the pressboard by the method prescribed in Annex K.

L-2 *p*H DETERMINATION

L-2.1 Determine the *p*H value by electrometric method at a temperature between 15 and 25°C as soon as possible after the preparation of the extract.

L-3 PRECAUTIONS

L-3.1 In the storage of samples of pressboard intended for the test for *p*H value, take care that they are not contaminated by the atmosphere, particularly the atmosphere of a chemical laboratory.

ANNEX M

(*Clause* 5.15)

DETERMINATION OF MOISTURE CONTENT

M-1 PROCEDURE

M-1.1 Weigh a test piece approximately 75 × 75 mm as received. Then dry the test piece in accordance with Annex S and after allowing it to cool in a desiccator to room temperature weigh it again. Calculate the loss in weight, namely the moisture content as a percentage of the original weight of the test piece.

ANNEX N

(*Clause* 5.16)

DETERMINATION OF MINERAL ASH

N-1 PROCEDURE

N-1.1 Dry not less than 2 g (a large sample up to 5 g may be necessary when testing a pressboard of low ash content) of pressboard at a temperature of 105 ± 2°C for 3 hours and then accurately weigh it to obtain the dry weight.

N-1.2 Ignite the sample to a constant weight at a temperature of 800°C to 900°C taking all precautions against loss and ensuring the absence of unburnt carbon in ash. Weigh the residue of incombustible matter (ash) and compute the amount as a percentage of the weight of the dry sample. Make a duplicate determination of the ash content, and if the two results do not agree to within 20 percent discard the results and repeat the tests. The higher of the two results is the mineral ash.

ANNEX P

(*Clause* 5.17)

DETERMINATION OF FREEDOM FROM CONDUCTING ARTICLES

P-1 TEST PIECE

P-1.1 Use test pieces not less than 30 cm wide and test at least 1 m^2 of the board.

P-2 CONDITIONING

P-2.1 It is not necessary to condition the pressboard before carrying out this test provided the material has been stored so as to attain the condition of ordinary room humidity.

P-3 PROCEDURE

P-3.1 Draw the test piece at a speed of approximately 6 m/min between an arrangement of overlapping rollers and a brass plate. A suitable form of apparatus is shown in Fig. 8. The rollers are of brass 25 mm long and 22 mm in diameter with edges rounded to a radius of 0.8 mm, the size of the apparatus being such that a test piece not less than 30 cm wide can be tested. The width of the sample should be more than the width of the roller to avoid flashover across the edges of the test piece.

P-3.2 Subject the test piece to an alternating voltage with a frequency of 50 c/s equivalent to 4.0 kV/mm of nominal thickness applied between the rollers and plate using a lamp or other suitable indicator to demonstrate the failure of the test piece.

NOTE – A resistance should be inserted in the testing circuit to limit the current so that the electrodes are not unduly damaged if a puncture occurs.

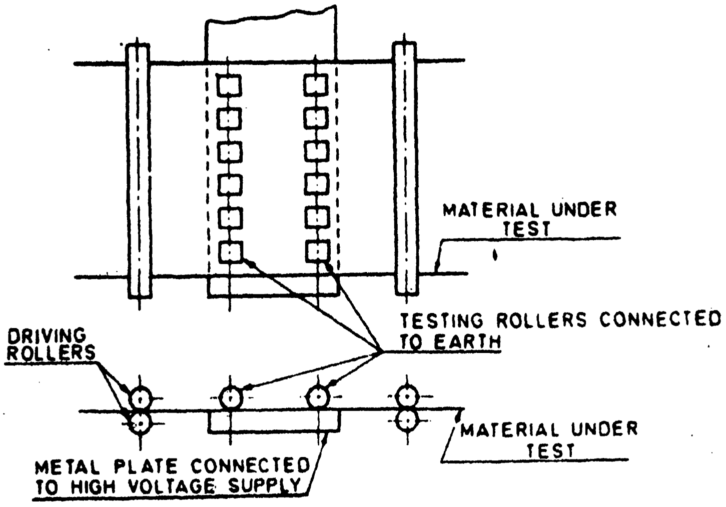

MATERIAL UNDER TEST
TESTING ROLLERS CONNECTED TO EARTH
DRIVING ROLLERS
MATERIAL UNDER TEST
METAL PLATE CONNECTED TO HIGH VOLTAGE SUPPLY

FIG. 8 DIGRAMMATIC ARRANGEMENT OF TEST APPARATUS FOR CONDUCTING PARTICLES

ANNEX Q

(*Clause* 5.18)

DETERMINATION OF CONDUCTIVITY OF ORGANIC EXTRACT

Q-1 APPARATUS

Q-1.1 Use a suitable coductivity cell such as that used for determining conductivity of aqueous extract, or the special cell shown in Fig. 9, in conjunction with an electronic multi-megohm meter using 85 V direct current or a sensitive galvanometer and battery. With the special cell Fig. 9, use an instrument capable of measurement over the range 0.5 megohms to 100 000 megohms.

Q-2 REAGENT

Q-2.1 Laboratory grade trichlorethylene purified by stirring in about 1 percent by weight of Fuller's earth and filtered through a sintered glass filter.

Q-2.1.1 Purified trichloroethylene is stable if kept in the dark or in a brown bottle but check its conductivity before use for an extraction. During extraction and measurement shield the solvent from strong light, especially direct sub-light, and store it in the dark.

Q-2.1.2 Carry out a blank test before each extraction and if the resultant conductivity constant exceeds 5×10^{-12} mhos/cm, further purify the solvent till its conductivity is not greater than this figure.

NOTE — Fuller's earth becomes ineffective if allowed to absorb moisture and may be dried by heating in clean air at a temperature not exceeding 120°C.

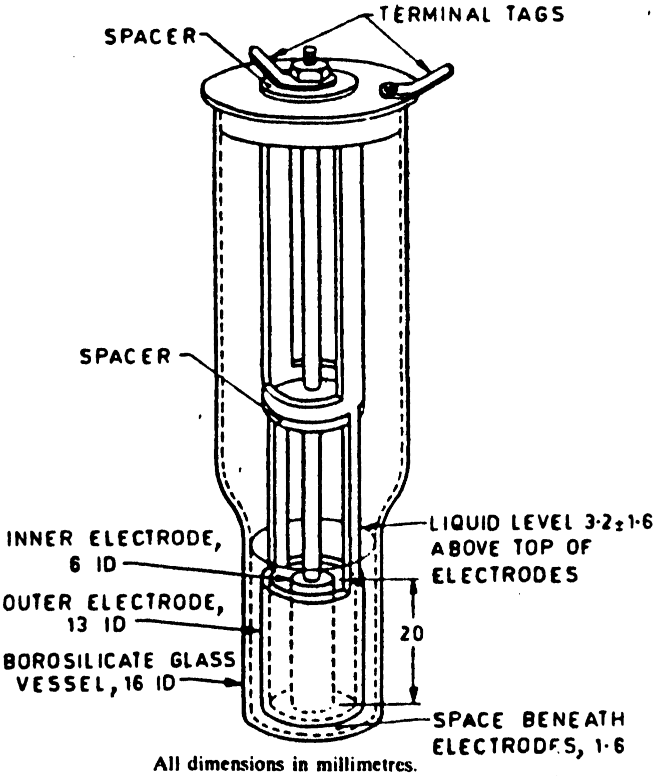
Q-3 PREPARATION OF EXTRACT

Q-3.1 Prepare the extract by cutting the material under test as described for conductivity of water extract in Annex K, gently heat the samples in air for about 2 hours at a temperature of 80°C to 100°C to remove any appreciable amount of absorbed water, and immediately transfer the material to a suitable flask and cover it with purified trichloroethylene using a proportion of 1 g to 10 ml of solvent. Boil the solvent gently for about 1 hour under reflux conditions using all glass apparatus constructed with ground glass joints. Firmly stopper the flask and allow it to remain overnight in the dark. Adjust any loss of volume through evaporation by adding pure solvent before making the conductivity measurement.

Q-4 METHOD OF MEASUREMENT

Q-4.1 If not already known, determine the cell constant *K* by means of an aqueous solution of known conductivity prepared and tested as described in Annex K. The 85 V dc instrument referred to above is not suitable for this determination.

Q-4.2 Before filling with the trichloroethylene extract, wash the cell thoroughly with distilled water (if last used with an aqueous electrolyte) dry it and clean it several times with purified trichloroethylene. Dry the


TERMINAL TAGS
SPACER
SPACER
INNER ELECTRODE, 6 ID
OUTER ELECTRODE, 13 ID
BOROSILICATE GLASS VESSEL, 16 ID
LIQUID LEVEL 3·2±1·6 ABOVE TOP OF ELECTRODES
20
SPACE BENEATH ELECTRODES, 1·6

All dimensions in millimetres.

FIG. 9 CELLS FOR DETERMINATION OF CONDUCTIVITY OF ORGANIC EXTRACT

cell before filling and arrange for the transfer of the liquid from one vessel to another to take place in a stream of warm air to avoid risk of moisture condensation resulting from cooling; avoid breathing on the electrodes.

Q-4.3 Measure the resistance of the extract at a temperature between 15°C and 25°C, 1 minute after application of the dc voltage. If the special cell shown in Fig. 9 is used, the inner electrode should be negative and the electrode earthed.

$$\text{Conductivity of the extract in mhos/cm} = \frac{K}{R}$$

where

K = cell constant, and
R = measured resistance of the extract in ohms.

NOTE – Correction for the conductivity of the solvent is to be applied as indicated above.

Q-5 PRECAUTIONS

Q-5.1 Ensure that in the storage of samples intended for test for conductivity of aqueous extract they are not contaminated by the atmosphere, particularly the atmosphere of a chemical laboratory.

ANNEX R

(*Clauses* B-2.1, D-2.1, G-2.1, H-2.1 *and* J-2.1)

CONDITIONING OF TEST PIECES

R-1 PROCEDURE

R-1.1 Condition the test pieces for not less than 18 hours in a controlled atmosphere of 65 ± 2 percent relative humidity and at a temperature of 27°C ± 2°C. Commence the relevant test within 3 minutes of removal of each test piece from the controlled atmosphere.

R-1.2 This atmosphere of 65 percent relative humidity may be obtained conveniently in an enclosed chamber in which a saturated solution of sodium nitrate is exposed to the atmosphere in the chamber. Prepare the saturated solution from distilled water and sodium nitrite of a recognized analytical reagent quality.

R-1.3 Expose the saturated solution so that the maximum surface is in contact with the air in the chamber, for example, by covering the floor of the chamber with a tray containing the saturated solution. It is essential to use an ample excess of solid sodium nitrite in contact with the saturated solution. If desired a mobile slurry of salt and saturated solution may be used, this being prepared by adding to the solid salt, of suitable particle size a previously prepared solution of sodium nitrite until the desired fluid consistency is obtained.

R-1.4 The saturated salt solution or slurry will become contaminated in the course of time; the salt tray should, therefore, be emptied, washed all over, carefully dried and refilled with sufficient saturated solution or slurry at intervals of not more than 2 months. More frequent changes may be necessary if the chamber is used where conditions of severe contamination are experienced. Ensure uniform throughout the chamber through the passage of fan-circulated air over the surface of the saturated solution or slurry and around the test pieces. Free access of the conditioning atmosphere to all test pieces is essential. From time to time, check that the humidity of the air in the chamber is correct.

ANNEX S

(*Clauses* C-1.1, D-5.1, D-5.2, F-7.1, G-2.1, G-3.1 (a), M-1.1)

DRYING OF TEST PIECES

S-1 PROCEDURE

S-1.1 Dry the test pieces in a ventilated oven at 105 ± 2°C for the relevant period stated below:

Nominal Thickness of Test Piece mm	*Drying Period* h
Up to 1.6	6
Above 1.6 and up to 4.75	30
Above 4.75	48

ANNEX T

(*Forewurd*)

TESTS RECOMMENDED FOR APPLICATION TO PRESSBOARD INTENDED FOR SPECIFIC USES

Forword

	USES	THICKNESS	DENSITY	ELECTRIC STRENGTH	TENSILE STRENGTH	COMPRESSION STRENGTH	COMPRESSION IN OIL	SHRINKAGE	FLEXIBILITY	COHESION BE-TWEEN PILES	OIL ABSORPTION	MACHINING TEST	CONDUCTIVITY OF AQUEOUS EXTRACT	pH OF AQUEOUS EXTRACT	MOISTURE CONTENT	MINERAL ASH	FREEDOM FROM CONDUCTING PARTICLES
Application in oil	Barriers	*	*	*	*	—	—	*	*	—	*	—	*	*	*	*	—
	Tank lining	*	*	*	*	—	—	*	*	—	*	—	*	*	*	*	—
	Terminal boards	*	*	*	—	*	*	*	—	*	*	*	*	*	*	*	*
	Spacing blocks, strips, washers	*	*		—	*	*	*	—	—	*	*	*	*	*	*	—
Application in Air	Cylinders made from boards	*	*	*	*	—	—	*	*	*	*	—	*	*	*	*	*
	Transformer washers	*	*	*	—	*	*	*	—	—	*	—	*	*	*	*	*
	Barriers	*	*	—	*	—	—	—	*	—	—	—	*	*	*	*	—
	Slot linings	*	*	*	*	*	*	—	*	*	—	—	*	*	*	*	*
	Armature, rotor & spot insulation	*	*	*	—	*	*	—	*	—	—	*	*	*	*	*	*
	Field coil washers	*	*	*	*	—	—	—	—	—	—	—	*	*	*	*	—

NOTE — '*' denotes the applicability of the test.

GMGIPN—80 BIS/ND/07—100

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Amendments Issued Since Publication

Amendment No.	Date of Issue	Text Affected

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Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002
Telephones: 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.org.in

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